# K* vector meson coupling to the $\Lambda(1520)$ resonance


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2005, Nov. 18th

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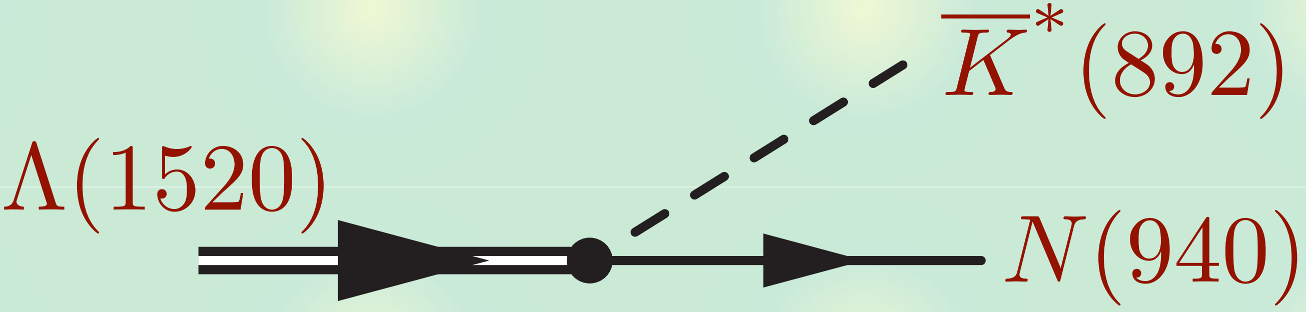


- Introduction to Λ(1520)
- Chiral unitary model
- Description of Λ(1520)
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# Introduction : Λ(1520)

$\Lambda(1520) : J^P = 3/2^-, I = 0$

**Mass : 1519.5 ± 1.0 MeV**

**Width : 15.6 ± 1.0 MeV**

**Decay modes :**

| | |
|---|---|
| $\Lambda(1520) \to N\bar{K}$ | **45%** |
| $\Lambda(1520) \to \Sigma\pi$ | **42%** |
| $\Lambda(1520) \to \Lambda\pi\pi$ | **10%** |

## (Naive) Quark model : SU(3) singlet

- ★ **large LS splitting with Λ(1405)?**
- ★ **decay branching ratio?**

# $\Lambda(1520)$ : recent interest

## Photo-production experiments

### Large p/n asymmetry?

**LEPS @ SPring-8, CLAS @ J-lab.**

**S.I. Nam *et al.*, PRD 71, 114012 (2005)**

### Importance of the K* exchange?

**D. P. Barber *et al.*, Z. Phys. C 7, 17 (1980)**

**A. Sibirtsev *et al.*, hep-ph/0509145**

## $\Theta^+$ $\Lambda^*$ coherent production on deuteron

**LEPS @ SPring-8**

**A.I. Titov *et al.*, PRC 72, 035206 (2005)**

# Chiral unitary model

**Chiral symmetry**

**Low energy behavior**

+

**Unitarity of S-matrix**

**Non-perturbative resummation**

**Scattering of 8 meson($0^-$) and 8 baryon($1/2^+$)**

**Dynamical generation**

$$J^P = 1/2^- \text{ resonances}$$

$$\Lambda(1405), \Lambda(1670),$$
$$\Sigma(1620), \Xi(1620),$$
$$N(1535)$$

# Chiral unitary model

**Chiral symmetry**

Low energy behavior

+

**Unitarity of S-matrix**

Non-perturbative resummation

**Scattering of 8 meson($0^-$) and 10 baryon($3/2^+$)**

**Dynamical generation** →

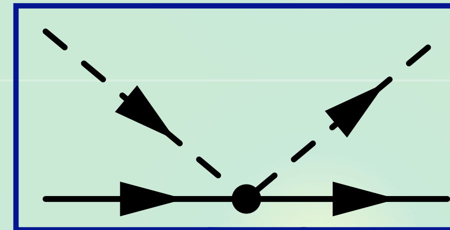
$J^P = 3/2^-$ resonances

$\Lambda(1520), \Sigma(1670), \Xi(1820), \ldots$

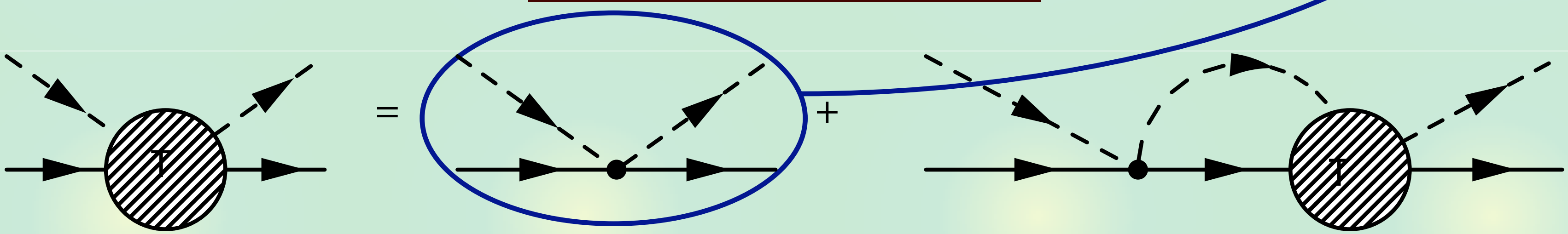
# Framework of the chiral unitary model

## Chiral perturbation theory

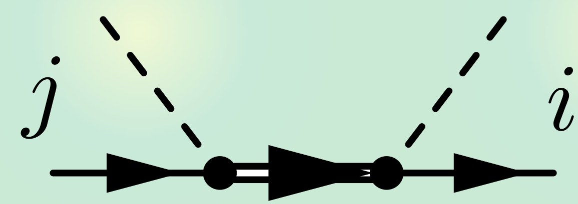
$$\mathcal{L}_{WT} = \frac{1}{4f^2}\mathrm{Tr}(\bar{B}i\gamma^{\mu}[(\Phi\partial_{\mu}\Phi - \partial_{\mu}\Phi\Phi), B])$$



## Unitarization




$$T_{ij}(\sqrt{s}) \sim \frac{g_i g_j}{\sqrt{s} - M_R + i\Gamma_R/2} + T_{ij}^{BG}$$

$\sim$ 

# Decuplet-Octet scattering

**Interaction of 8 meson and 10 baryon is derived from chiral perturbation theory**

E. Kolomeitsev *et al.*, PLB 585, 243 (2004)
S. Sarkar *et al.*, NPA 750, 294 (2005)

**non-relativistic reduction + s-wave**

$$V_{ij} = -\frac{1}{4f^2} C_{ij}(k^0 + k'^0)$$

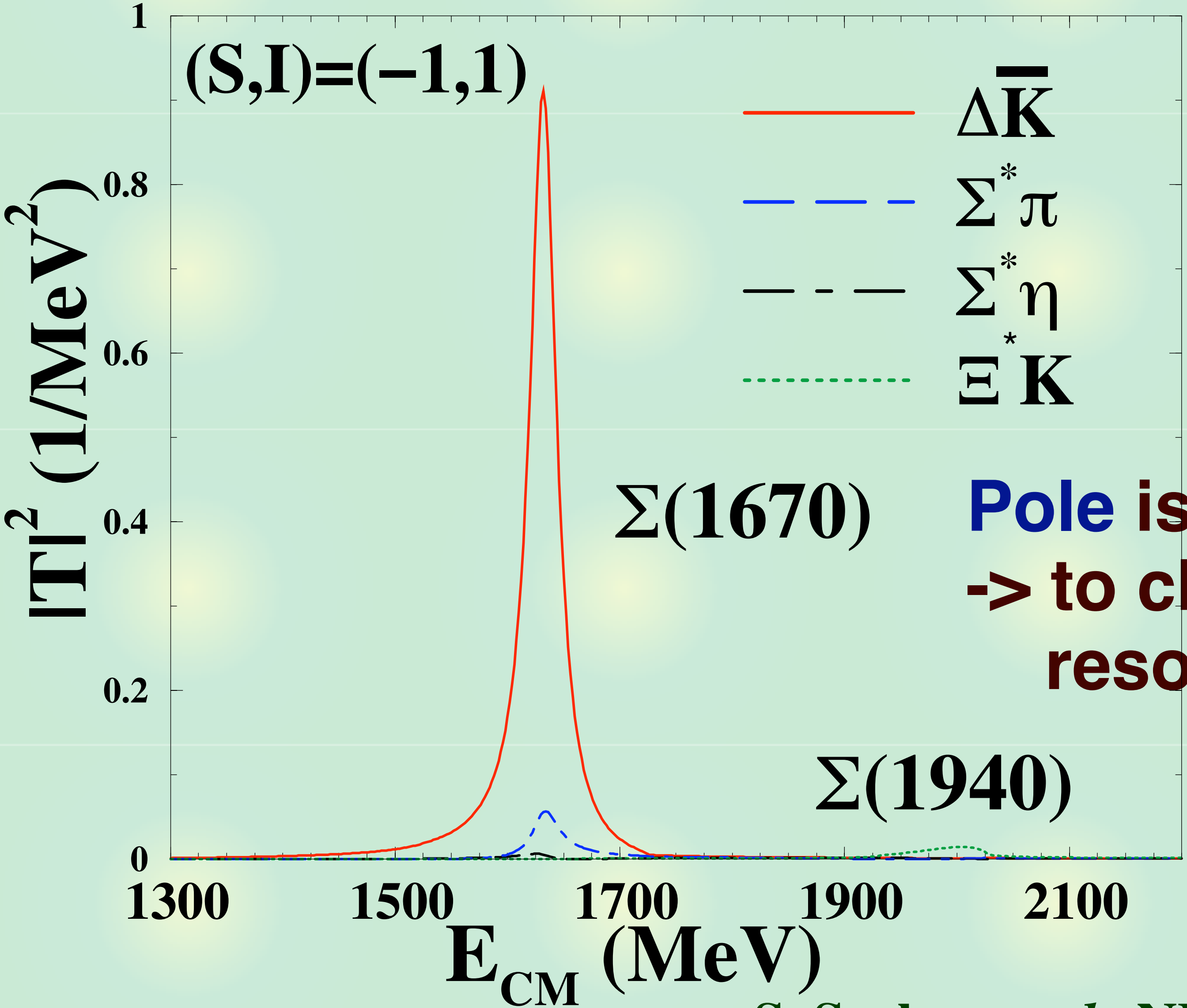
**-> same structure as 8–8 scattering**

**SU(3) decomposition**

**$8 \times 10 = 8 + 10 + 27 + 35$ repulsive**

**attractive weakly attractive**

# Results for the Decuplet-Octet scattering

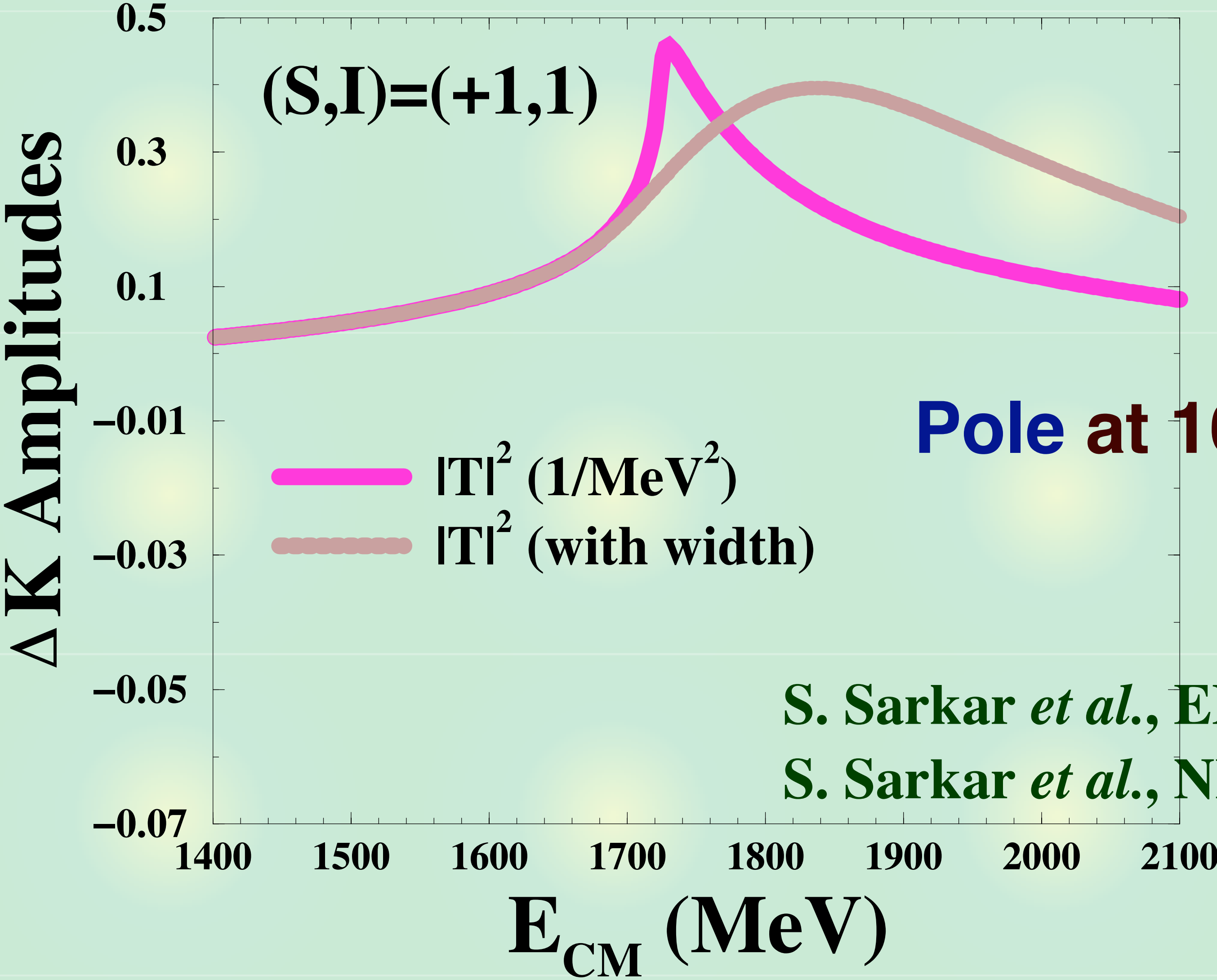



**Pole** is searched for
-> to check whether
resonance or not

S. Sarkar *et al.*, NPA 750, 294 (2005)

# Results for the exotic state?

**8 × 10 = 8 + 10 + 27 + 35** weakly attractive



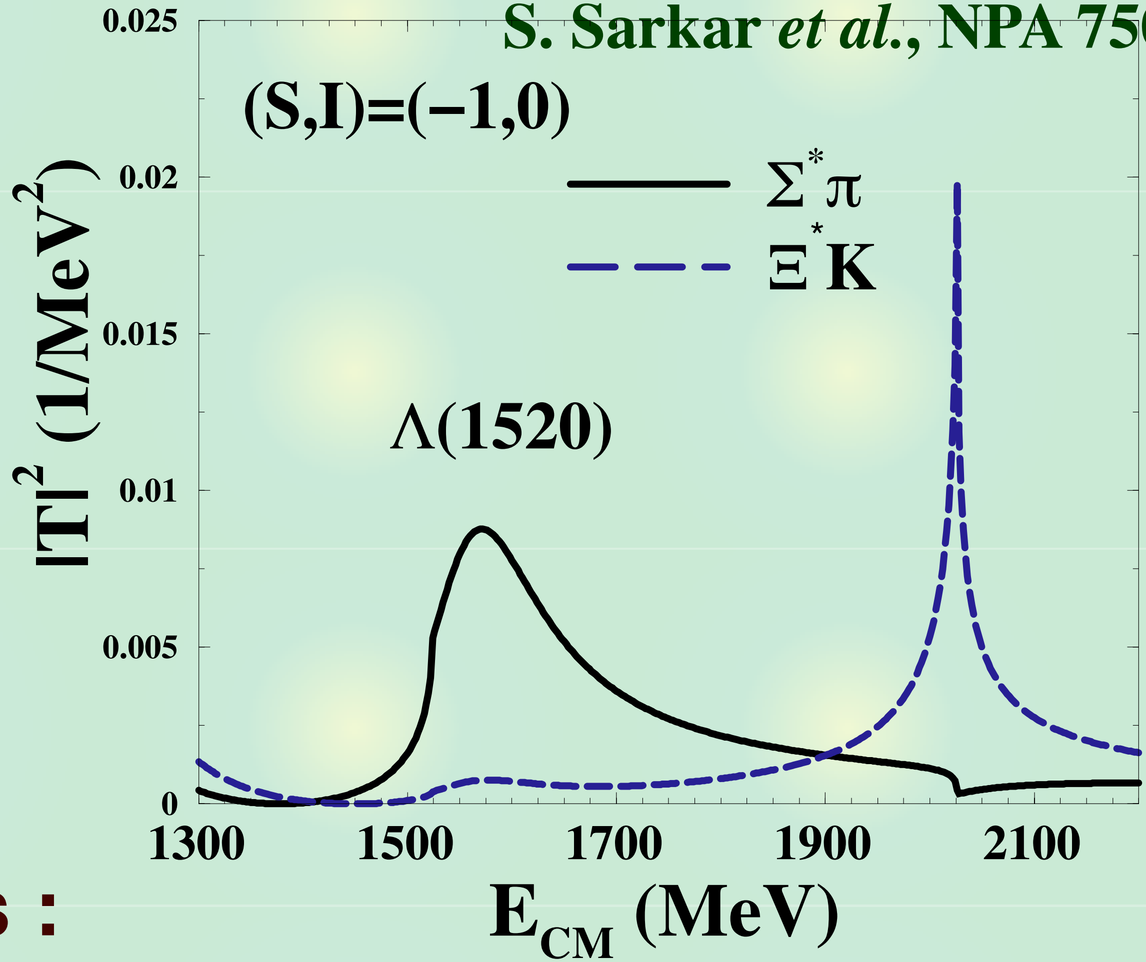

**Pole at 1635 MeV**

S. Sarkar *et al.*, EPJ A24, 287 (2005)

S. Sarkar *et al.*, NPA 750, 294 (2005)

# Result for Λ(1520)

S. Sarkar *et al.*, NPA 750, 294 (2005)




**Caveats :**

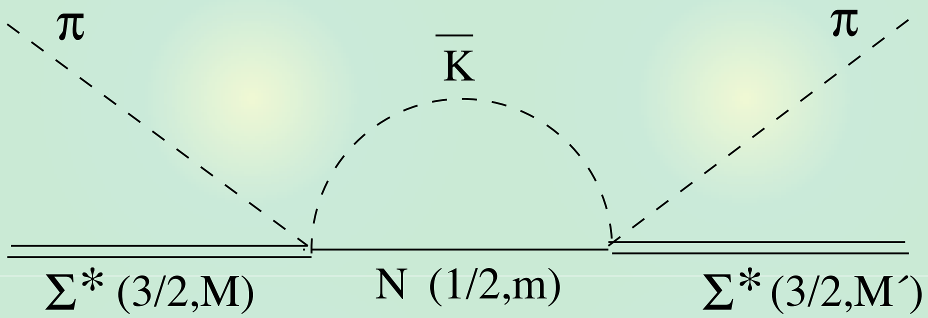
- ★ Decuplet baryons do not decay
- ★ No coupling to other MB channels

-> Results should be regarded as qualitative

# Quantitative description of Λ(1520)

## More quantitative description

-> include **d-wave channels** : $\bar{K}N$, $\pi\Sigma$

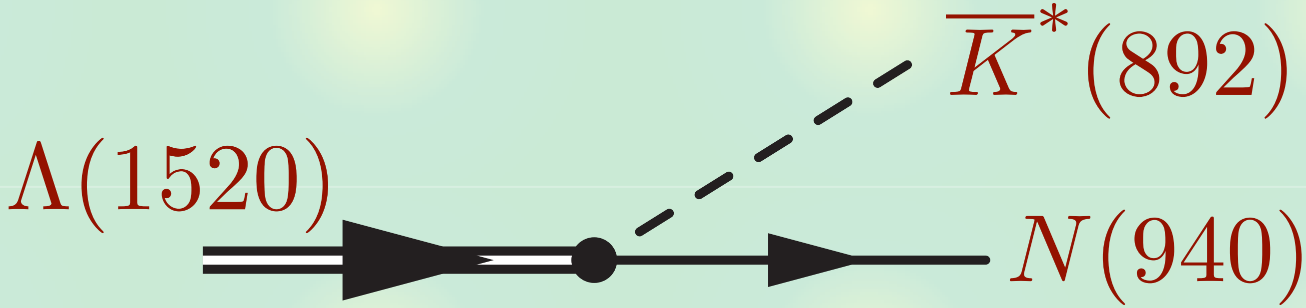



## Additional coupling constants

-> Decay width, branching ratio are reproduced

S. Sarkar *et al.*, PRC 72, 015206 (2005) -> K induced reaction
L. Roca *et al.*, in preparation -> photon, π induced production
M. Döring *et al.*, in preparation -> radiative decay

# Formulation




## Effective interaction Lagrangian

$$\mathcal{L}_{\Lambda^*\bar{K}^*N} = \frac{g_{\Lambda^*\bar{K}^*N}}{M_{K^*}}\bar{\Lambda}^*_\mu \gamma_\nu (\partial^\mu K^{*\nu} - \partial^\nu K^{*\mu})N + h.c.$$

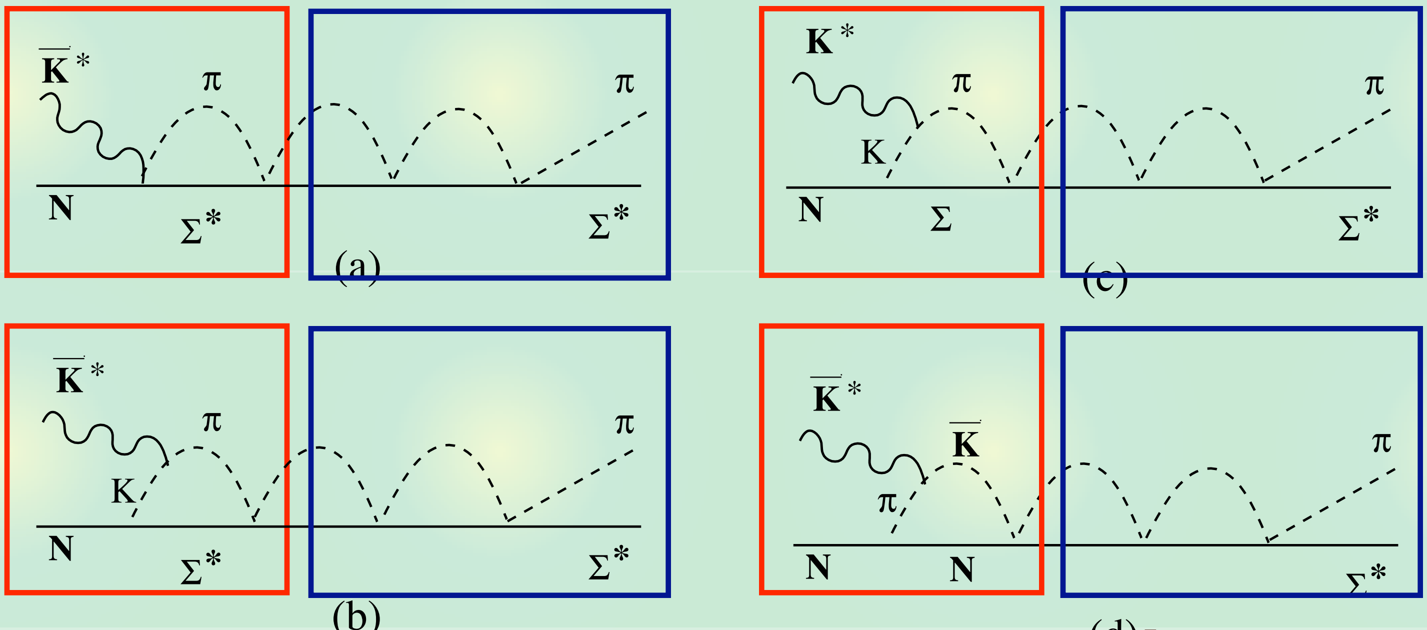
## Non-relativistic reduction (s-wave)

$$-it_{\Lambda^*\bar{K}^*N} = g_{\Lambda^*\bar{K}^*N}\boldsymbol{S}\cdot\boldsymbol{\epsilon}$$

# Formulation

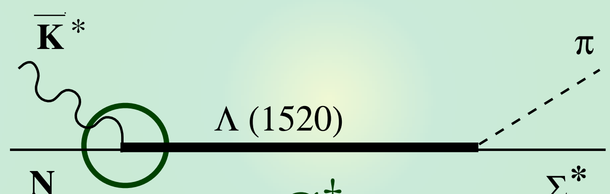
## Amplitude for $\bar{K}^* N \to \pi \Sigma^*$

**Microscopic couplings** **Chiral unitary model**




## Resonance dominance

$$\sqrt{s} \sim M_{\Lambda^*}$$




$$g_{\Lambda^* \bar{K}^* N} \boldsymbol{S}^\dagger \cdot \boldsymbol{\epsilon}$$

# Formulation

**Calculated by evaluating diagrams**

$$g_{\Lambda^* \bar{K}^* N}(P_0, k) = g_{\Lambda^* \pi \Sigma^*} \left[ G_{\pi \Sigma^*}(P_0) + \frac{2}{3} \tilde{G}_{\pi \Sigma^* K}(P_0, k) \right] g_{\pi \Sigma^* \bar{K}^* N}$$

$$+ g_{\Lambda^* \pi \Sigma} \tilde{G}_{\pi \Sigma K}(P_0, k) g_{\pi \Sigma \bar{K}^* N} + g_{\Lambda^* \bar{K} N} \tilde{G}_{\bar{K} N \pi}(P_0, k) g_{\bar{K} N \bar{K}^* N}$$

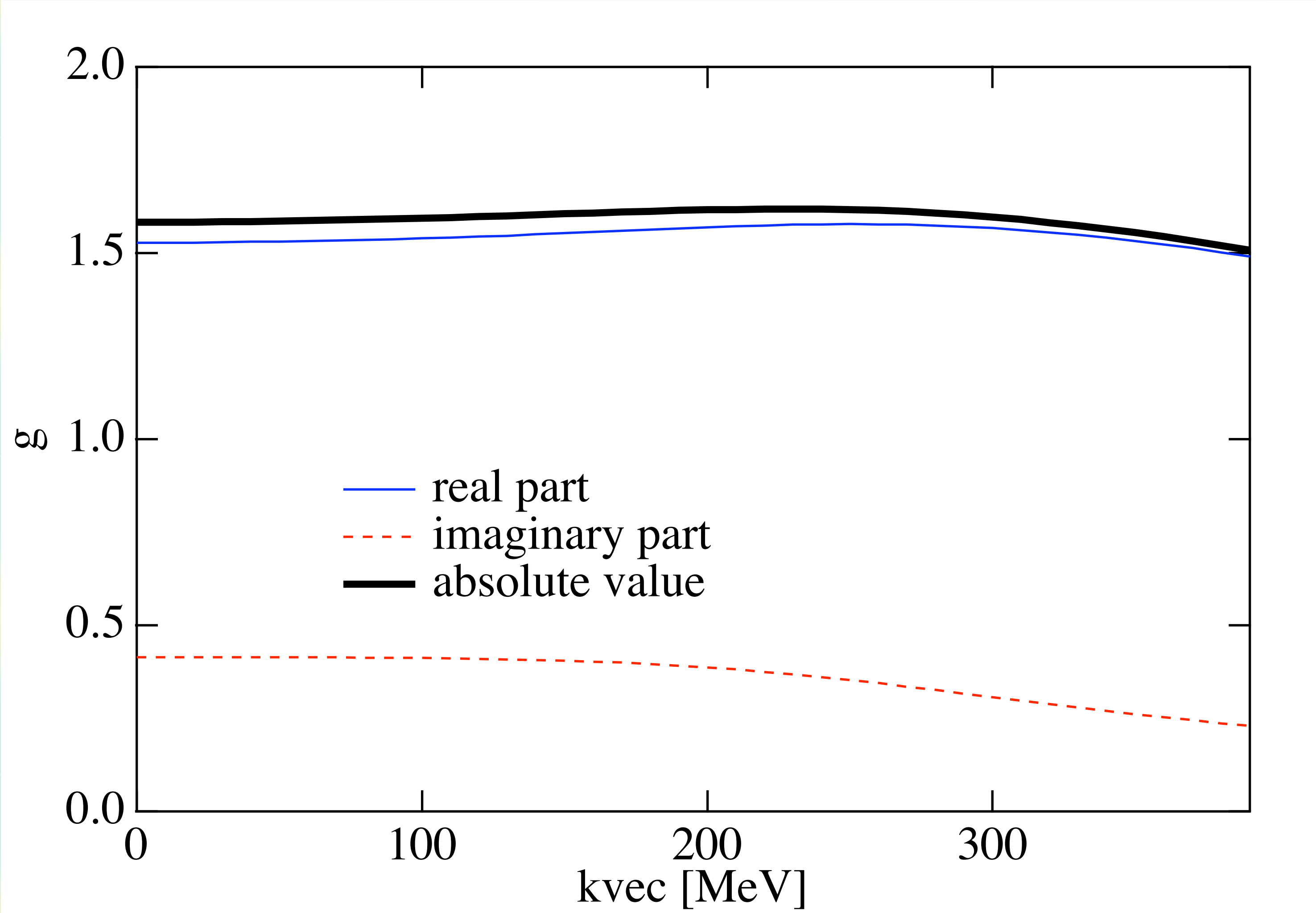
**Residue of the pole in chiral unitary mdoel**

**Evaluate this at**

$P_0 = 1520\ \mathrm{MeV}$ **(resonance dominance)**

$k \sim 0\ \mathrm{MeV}$ **(s-wave dominance)**

# Numerical result




**Small number : |g| ~ O(1)**

# Comparison with other estimations

Chrial unitary model : $|g| \sim O(1)$

Quark model

pure singlet : $g \sim 20$

mixing with octet : $g \sim 10$

Fitting by Regge model to experiment

$g = +7.1$ or $-12.6$

Chrial unitary model gives a small number.

# Summary : mixing scheme

## We calculate the $\bar{K}^*N$ coupling to the Λ(1520) in the chiral unitary model

- The Λ(1520) is generated dynamically in the 8meson-10baryon scattering with phenomenological couplings to the d-wave 8meson-8baryon channels.
- The obtained coupling constant is small compared with the quark model result.
  - ★ difference of quark structure?
  - ★ difference of SU(3) structure?

Further investigation is needed.